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REPORT OF LABORATORY TESTS, OAK RIDGE NATIONAL LABORATORY SEWAGE

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REPORT OF LABORATORY TESTS
OAK RIDGE NATIONAL LABORATORY SEWAGE

O.R. Placak
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JUN 23 1949

I. Statement and Purpose

At the request of and with the cooperation of the Austin Company, laboratory studies were conducted on samples of sewage collected, over a forty-eight hour period, from two manholes in the X-10 Area. These samples were collected for the purpose of determining the solids and biochemical oxygen demand (BOD) characteristics of the sewage and their variation with time. These data are considered essential to the design of sanitary sewage treatment facilities for the X-10 Area.

II. Methods of Sample Collection and Analysis

All samples were collected by representatives of the Austin Company on June 1-3, 1949, inclusive, at intervals of one hour. During the period 9 AM June 1 to 9 AM June 2, the samples were collected hourly on the hour, and on the half hour from 9:30 AM June 2 to 8:30 AM June 3 from manhole (MH) 38. Samples were collected 15 min. after the hour and after the half hour, respectively from MH-107.

After collection, the samples were placed in one-quart Mason jars and iced. At the time of collection the following items were noted on the jar label; MH number, date and time of collection,

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temperature, flow, and the name or initials of the sample collector. Flow measurements were made at either of two weir boxes serving the respective sewer lines. These weir boxes were installed at the point where the sewers discharge into creeks in the area and measure the flows after passage through septic tanks.

ORNL, Waste Disposal Research personnel collected the iced samples at four hour intervals, processed the samples and made the necessary chemical analyses. These included the determination of pH, total and suspended solids, and the preparation, initial dissolved oxygen analyses and incubation of suitable samples for the determination of 5-day BOD from each of the hourly samples. Composite samples based on flow measurements were prepared from each group of four hourly samples taken from each manhole, and similar determinations were made on these samples.

The remaining sample material was again combined for studies utilizing ferric chloride as a coagulating or precipitating chemical.

III. Results of Laboratory Analyses

The data obtained are summarized in various tables and figures attached (See Tables 1 and Figures 1 to 6). Table 1 shows the average characteristics of ORNL sewage during the sampling period.

Table 1

Average Characteristics of ORNL Sewage

June 1-3, 1949

Sample Location	Flow g.p.m.	Temp. °C	pH	Total Solids p.p.m.			Suspended Solids - p.p.m.			Dissolved Solids - p.p.m.			5 Day B.O.D. p.p.m.
				Total	Volatile	Ash	Total	Volatile	Ash	Total	Volatile	Ash	
MH-38	77.8	34.9	7.4 - 8.1	280	135	146	64	42	22	216	93	124	57
MH-107	54.4	22.7	7.2 - 7.9	253	121	132	50	42	8	203	79	124	53

Flow. As previously stated, all flow measurements were made at two V-notch weirs located beyond the discharge or effluent end of two septic tanks. The weir box measuring the flow of sewage in MH-38 discharges into the small creek flowing in front of Building 703-C, and the weir box serving MH-107 discharges directly into White Oak Creek. All domestic sewage from the X-10 Area discharges into White Oak Creek and White Oak Lake and Reservoir.

Flow data for MH-38 and 107 are shown in Figure 1. The upper curves of Figure 1 indicate the flow in gallons per minute as ordinates plotted against time of observation as abscissae. Average flow rates are also noted and were found to be 77.8 and 54.4 gpm for MH-38 and MH-107, respectively. These data have been re-plotted in the lower curves of Figure 1 with the ordinate values represented in terms of the daily average value on a percent basis. These curves indicate that flows were below average for approximately 14 hours (from 5 PM to 7 AM) on both days with slightly lower values reported during the first period.

Temperature. Temperature readings, in degrees centigrade, were taken following collection of the samples. The average temperature for the sewage collected from MH-38 was 34.9°C. with a range of 28-39.5°C.; and for MH-107 the average temperature was 22.7°C. with a range of 21 - 26°C.

pH. Colorimetric pH measurements were made with cresol red and phenol red as indicators. For MH-38, the pH varied between the limits 7.4 and 8.1, and for MH-107 from 7.2 to 7.9.

Total Solids. Total solids were determined by evaporating 100 ml. of sample to dryness, maintaining at 103°C for one hour, and weighing. Through ashing the dry solids, the volatile fraction was determined.

The two day averages for total solids, volatile solids, and ash for MH-38 were 280, 135, and 146 ppm, and for MH-107 they were 253, 121, and 132 ppm, respectively. Figure 2 shows a plot of total solids discharged per hour during the 48-hour period based upon the average value of total solids.

Suspended Solids. This solids characteristic was determined by filtering 100 ml. of the sample through a previously prepared Gooch crucible provided with an asbestos mat. After drying, for one hour at 103°C, the sample was weighed and the dry solids determined. The sample was then placed in a muffle furnace for a period of 1/2 hour at a temperature of 600°C and the weight of ash was then found.

The two-day averages for suspended solids, volatile and ash were 64, 42, and 22 ppm for samples taken from MH-38 and 50, 42, and 8 ppm for samples collected from MH-107, respectively. The varia-

tion in suspended solids with time based upon the average suspended solids is shown in Figure 3.

Dissolved Solids. Dissolved solids were obtained by the difference between the total and suspended solids. The average values of total, volatile and ash for MH-38 were 216, 93, 124 ppm., and for MH-107 were 203, 79, and 124 ppm.

Biochemical Oxygen Demand. This test was run to determine the oxygen requirements of the sewage. The sewage samples are diluted with adequate amounts of Formula C dilution water (See Standard Methods for the Examination of Water and Sewage) and placed in 250 ml. glass-stoppered bottles without the entrainment of air. Each sample was set up in 4 bottles, two of which were titrated for initial dissolved oxygen (DO) content, and the remaining two were placed in a 20°C. incubator or in a constant temperature room (approximately 20°C.) for a period of 5 days. After the 5-day incubation period, the remaining bottles were titrated with $\frac{N}{40}$ sodium thiosulfate and the DO remaining in the sample was noted. The difference between the dissolved oxygen at the start and the end of the 5-day period, corrected for the oxygen demand of the dilution water blank, divided by the concentration of sewage in the dilution expressed as a percent results in the 5-day BOD. The 5-day samples were run at 5 days plus or minus 0 to 8 hours.

For the sewage samples from MH-38 and 107, the average 5-day BOD values were found to be 57 and 53 ppm, respectively. The BOD discharged hourly as a percent of the average value is shown in Figure 4.

Chemical Precipitation. Composite samples, of the remaining sewages, were prepared and coagulated through the addition of 2 or 3 grains of ferric chloride per gallon of sewage. Based upon the initial values for BOD and suspended solids there were reductions in these constituents of 82 and 95 percent at the 2 gpg. dosage rate, and 86 and 93 percent at the 3 gpg. dosage rate, respectively, due to the chemical treatment. The BOD of the samples under investigation was reduced from an average of approximately 19 ppm to 3 ppm, and the suspended solids from an average of approximately 5.5 ppm to 0.5 ppm at the 2 gpg dosage rate.

These samples had stood so long, with consequent change in sewage composition, before we were able to perform these tests that these data possess little value. If chemical precipitation is to be considered an evaluation with fresh samples must be made. The significant fact ascertained in these tests is that there is nothing to indicate that chemical precipitation could not be successfully used with this sewage provided the sewage remains the same as at the time of

sampling. However, these data are considered inconclusive and warrant no further consideration without additional tests.

IV. Discussion

To obtain information on the concentration of municipal sewages and the results to be expected from various methods of treatment, data were collected from published reports and these are summarized in Table 2. These data show that the raw sewage values obtained during the 48-hour period reported herein were considerably lower in suspended solids and 5-day BOD (58 and 55 ppm, respectively)* than the average effluent resulting from primary treatment of municipal sewage. Only the activated sludge, trickling filter and chemical processes produced final effluents superior to our present raw sewage values.

It is not known with certainty as to what reduction in suspended solids or BOD may be expected with the activated sludge process or trickling filter process here because of the very dilute and weak sewages available for treatment. It is quite evident that the same percentage reduction cannot be expected here as is obtained in the treatment of municipal sewages with four times the concentration of suspended

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* Combined averages based on average flows and average suspended solids and BOD at each MH.

Table 2

Data From Representative Sewage Treatment Plants

Type of Treatment	Number of Plants	Average Flow mgd	Suspended Solids Influent	Suspended Solids Effluent	5-Day BOD - P.P.M. Influent	5-Day BOD - P.P.M. BOD Effluent
Primary	14	8.49(5-413)*	192(30-290)	98(25-160)	197(131-384)	132(68-208)
Chemical Fptn.	1	8.6(0.036-23.5)	220(58-339)	41(10-82)	200(86-339)	66(12-140)
Guggenheim	1	10.29	251	35	195	48
Trickling filter	5	17.2(3.1-23.9)	242(193-285)	43(32-56)	199(144-314)	27(22-31)*
Biofiltration 1-stage	29	14.3(6.8-21.8)**	253(146-472)	61(32-91)	223(115-774)	27(8-169)
Biofiltration 2-stage	15	45.6(2-108)**	321(180-616)	66(17-185)	408(151-825)	53(13-217)
Activated Sludge	35	39.6(1.1-352)	227(115-427)	19(5-62)	203(87-423)	19.5(4.3-62)

* Values in parentheses are minimum and maximum, respectively.

** Flow data - average of 3 values.

solids and oxygen consuming substances. In addition, operating difficulties will no doubt arise, particularly in the use of the activated sludge process because of the very low solids concentration and the effect this will have on mixed liquor solids concentration.

The plotted data (Figures 2 to 4, inclusive) indicate that the major portion of the sewage solids and BOD are discharged over relatively short periods of time during the daylight hours (7 AM to 5 PM). During the remainder of the period, the suspended solids concentration and the BOD may be considered quite negligible. In fact, the concentration of suspended solids and the BOD in the sewages during the late evening and early morning hours is lower than that indicated for any of the sewage effluents from secondary treatment. These flows could be by-passed without exerting an appreciable effect upon the receiving stream.

Rough measurements of White Oak Lake waters indicate that, during this sampling period, approximately 5,522 pounds of dissolved oxygen were available for stabilizing whatever sewages were discharged into the lake. Based upon the BOD of the sewage discharged, 103 pounds of dissolved oxygen would be required to satisfy the 5-day BOD or 152 pounds of dissolved oxygen would satisfy the ultimate demand of the carbonaceous stage BOD of the sewage. This would lower the dis-

solved oxygen content of the Lake to 5370 pounds and would be equivalent to reducing the dissolved oxygen content at the 3 foot level from approximately 7.8 p.p.m. to approximately 7.6 p.p.m. (Based upon the assumption that conditions in the lake would remain substantially the same as at the time the observations for dissolved oxygen were made). These computations are based upon the assumption that the dissolved oxygen changes uniformly throughout the entire mass of water, and that in keeping with our rough measurements, there is no dissolved oxygen below a lake depth of 10 feet.

Consideration must be given to the fact that the White Oak Lake system may serve, in fact, as a means of secondary treatment. When the White Oak Lake Reservoir is at elevation 750 feet, approximately 14.5 million cubic feet (or 108 million gallons) of water will be stored. With a sewage flow of 200,000 gpd, it can be seen that the detention period in the reservoir will be very long. Assuming further that the entire suspended solids content will be deposited, the rate at which sludge banks will accumulate is approximately as follows: 92 pounds of suspended solids will be discharged daily or approximately 17 tons per year. With no allowance for compaction and digestion, this weight of suspended solids will occupy a volume of 340 cubic feet or approximately 0.002% percent of the reservoir capacity per year.

The flow characteristics are unusual as indicated by Figures 1, 5, and 6. Minimum values are very close to average flow values. This may possibly be explained by the fact that flow measurements were made beyond the septic tanks and that these tanks may have had a tendency to even-out the flow. This will occur, but whether the flow will be evened-out to the extent indicated by the flow data is somewhat questionable. The flow data seem to show that there is a continuous discharge of large volumes of clean waters from some unknown source, or that there ia a very large amount of ground water finding its way into the sewers. The samples collected during the early evening and early morning hours resembled clean water with very low suspended solids contents and low BOD values. It would be desirable to obtain information on the source of these flows.

Reference to Figures 5 and 6 will indicate further that the flow measurements are most unusual. In these figures, the pounds of flow, suspended solids and BOD are plotted, against time, as cumulative percentages of the total flow, suspended solids, and BOD discharged in pounds daily. As expected, the suspended solids and 5-day BOD data show a sharp increase in the quantity of these materials present in sewages discharged during the day-time hours with a leveling off during the late evening and early morning hours. However, the plot for flow seems to follow an unusually straight line indicating that the flow is relatively constant throughout the day.

V. Conclusions

The conclusions stated below must be considered from the viewpoint of these restrictions:

(a) They are based solely on an analysis of the data obtained during the forty-eight hour sampling period and apply to these data with no regard for future changes, and

(b) They are based on the possibilities of treating sanitary sewage alone, with no consideration for any subsequent addition of industrial wastes.

Subject to the above limitations, the following statements may be made:

1. The source of the high night-time flows should be determined and, if other than ground water, these should be diverted to storm drains. If these large flows are the result of ground water infiltration, it would be advisable to insure tight joints in the sewer lines to minimize infiltration.

2. The low average concentrations of solids and BOD in the raw sewage samples, collected during the period from June 1 - June 3 inclusive, may interfere with normal operation of either primary or secondary units. This is particularly true insofar as secondary treatment facilities are concerned. Prior to the design of new primary treatment facilities, Item I should have been accomplished. This should permit the use of considerably smaller primary treatment units (by a factor of 3 or 4). In the interim, the existing septic tank facilities, followed by chlorination should prove satisfactory.

The discharge of these wastes into White Oak Lake will have little effect upon the depletion of oxygen or on sludge bank formation in the lake. Dilution with Clinch River water, a short distance below the existing dam, further minimizes this problem from a public health standpoint.

3. Item 2 may be qualified by the following statements:

(a) There is some possibility for the creation of nuisance conditions, either from floating solids or sludge deposition, in White Oak

Creek, although this area is flushed frequently by rains and receives a dialy discharge of 200,000 - 400,000 gallons from the settling basin. If nuisance conditions arise, primary treatment will alleviate this condition to some extent.

(b) If the present septic tanks are continued in service floating solids would of course be removed. A necessary step would be to evaluate their construction, capacity and the quality of the effluent. It should be understood that a septic tank is one of the lower types of sewage treatment and if used, adequate operational and maintenance procedures should be set up and followed.

(c) If primary sedimentation is used, it should be realized, that at the present, volume of flow rather than sewage characteristics would be the deciding factor and that efficiencies of removal would be substantially less than those obtained in municipal practice.

(d) If the diluting water is removed, this sewage would approach a normal sewage and we are in agreement that primary sedimentation should be considered. Secondary treatment would also be feasible, in this event, but justifiable only for research purposes at the present time.

4. These data seem to indicate that the best that we can hope for, from a research point of view, is a more normal sewage accomplished by removal of diluting water. If research regarding the effect of radioactive materials on sewage treatment processes is to be carried on, it will be necessary to provide for this at a later date as a part of the research program.

5. There is one phase of the problem that cannot be discussed with certainty at the moment but should be mentioned. This is the possibility of discharged organic matter acting as nuclei for the concentration and adsorption of radioactive material. If later studies indicate this to be harmful, then steps should be taken to reduce the organic content to a minimum by the proper degree of treatment.

Acknowledgements

The assistance of the following representatives of the Waste Disposal Research section is greatfully acknowledged: Robert A. Lauderdale, Thomas W. Brockett, Thomas R. Ostrom, and Stanley Lyle. In addition we acknowledge the cooperation of the Austin Company in arranging for and providing sample collectors.

ORP:CPS:bab/rr

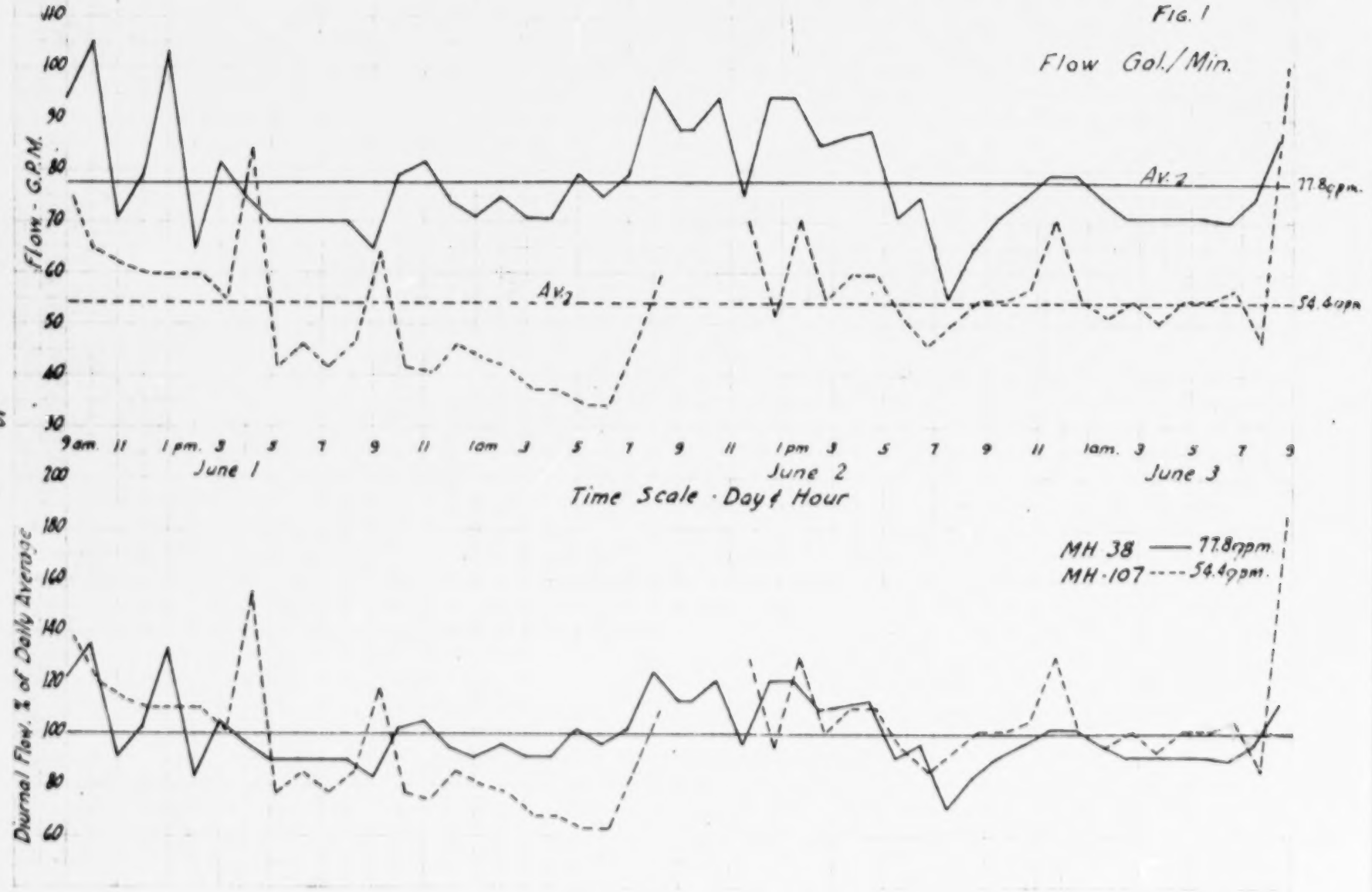
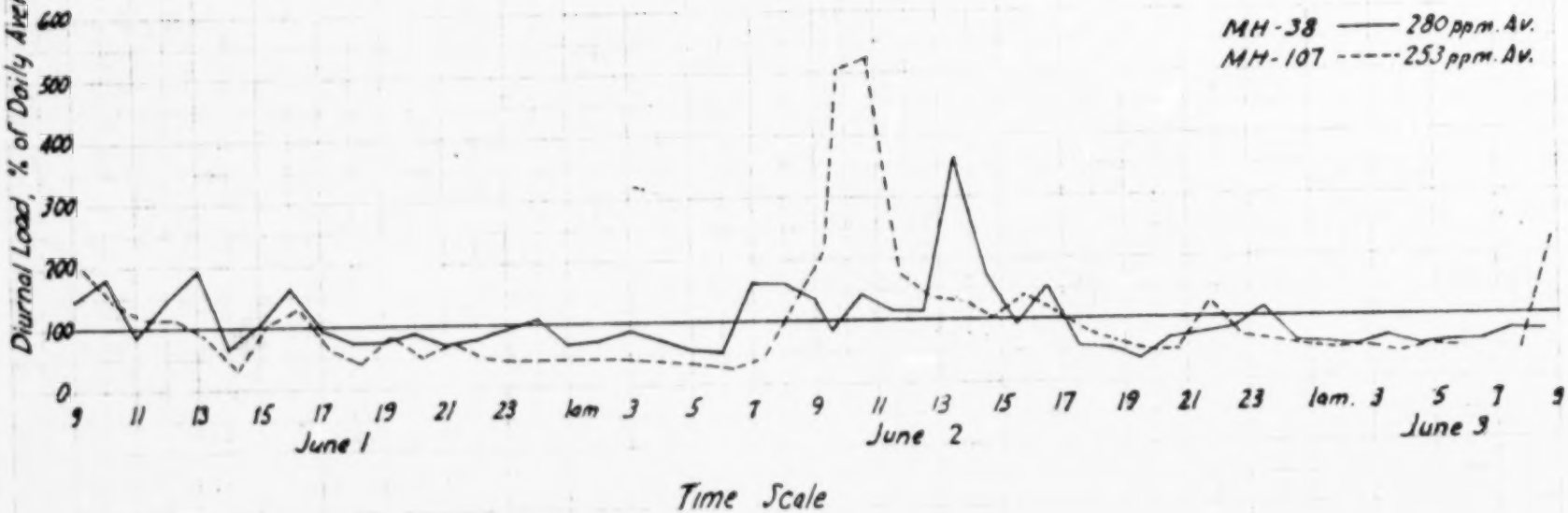

Flow Gal./Min.
Flow - G.P.M.
110
100
90
80
70
60
50
40
30
Av. 2
77.8 gpm.
Av. 1
54.4 gpm
9am 11 1pm 3 5 7 9 11 1am 3 5 7 9 11 1pm 3 5 7 9 11 1am. 3 5 7 9
June 1
June 2
June 3
Time Scale · Day & Hour
Diurnal Flow, % of Daily Average
200
180
160
140
120
100
80
60
MH 38 —— 77.8 gpm
MH-107 ---- 54.4 gpm.

FIG. 1

81

FIG. 2.

TOTAL SOLIDS CONC.



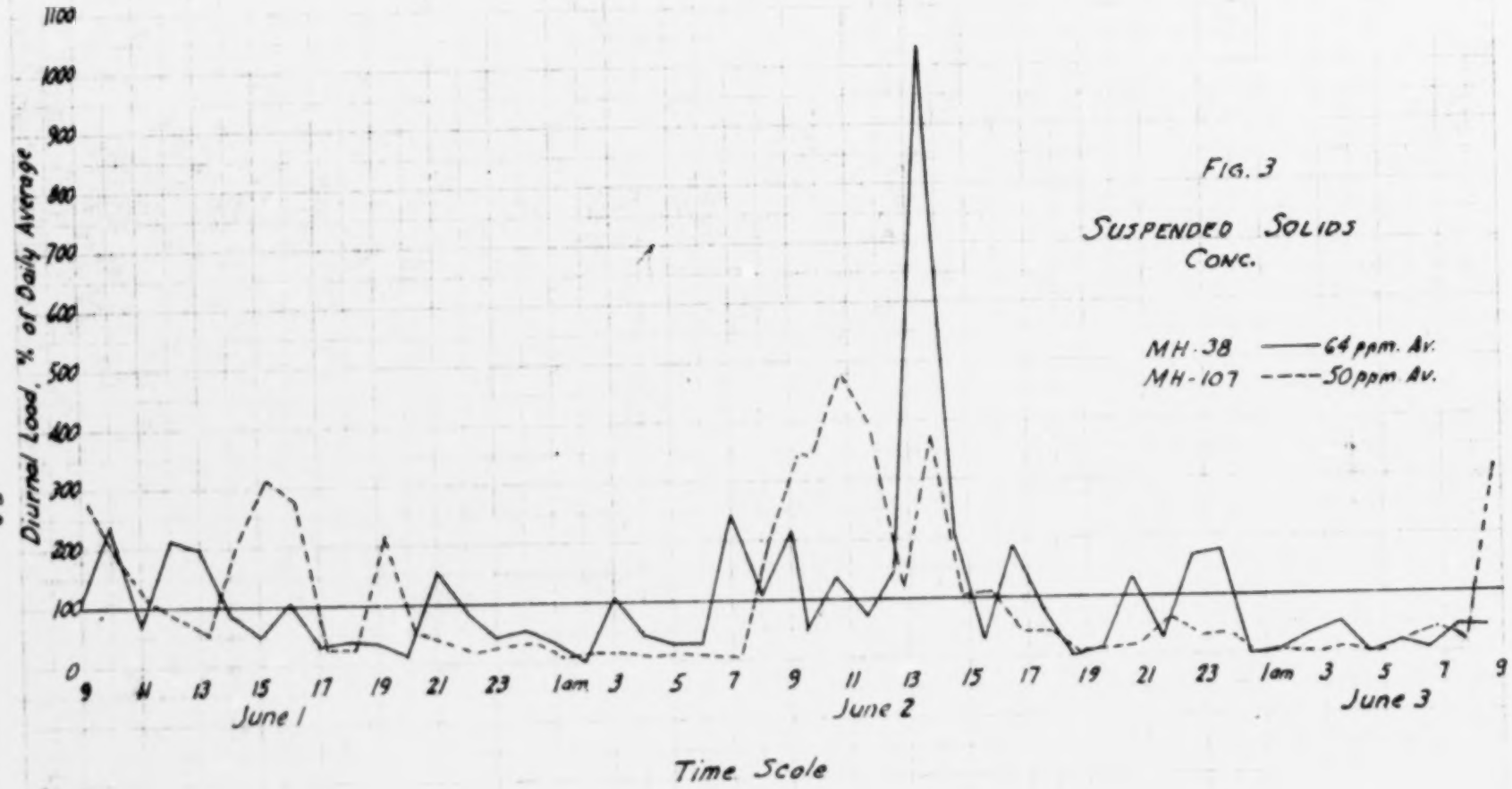


FIG. 3

SUSPENDED SOLIDS CONC.

MH-38 —— 64 ppm. Av.
MH-107 ---- 50 ppm Av.

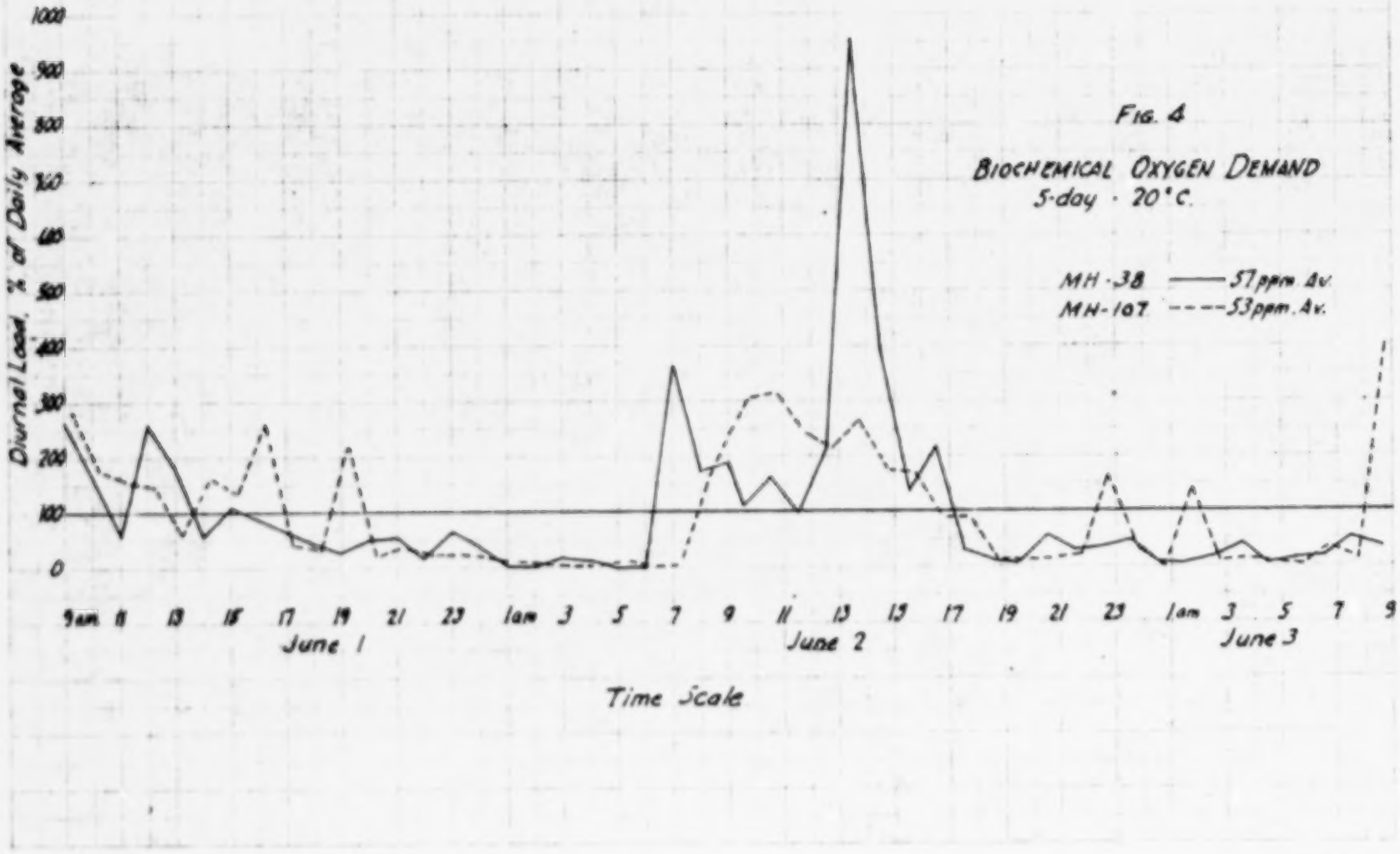


Fig. 4

Biochemical Oxygen Demand
5-day · 20°C.

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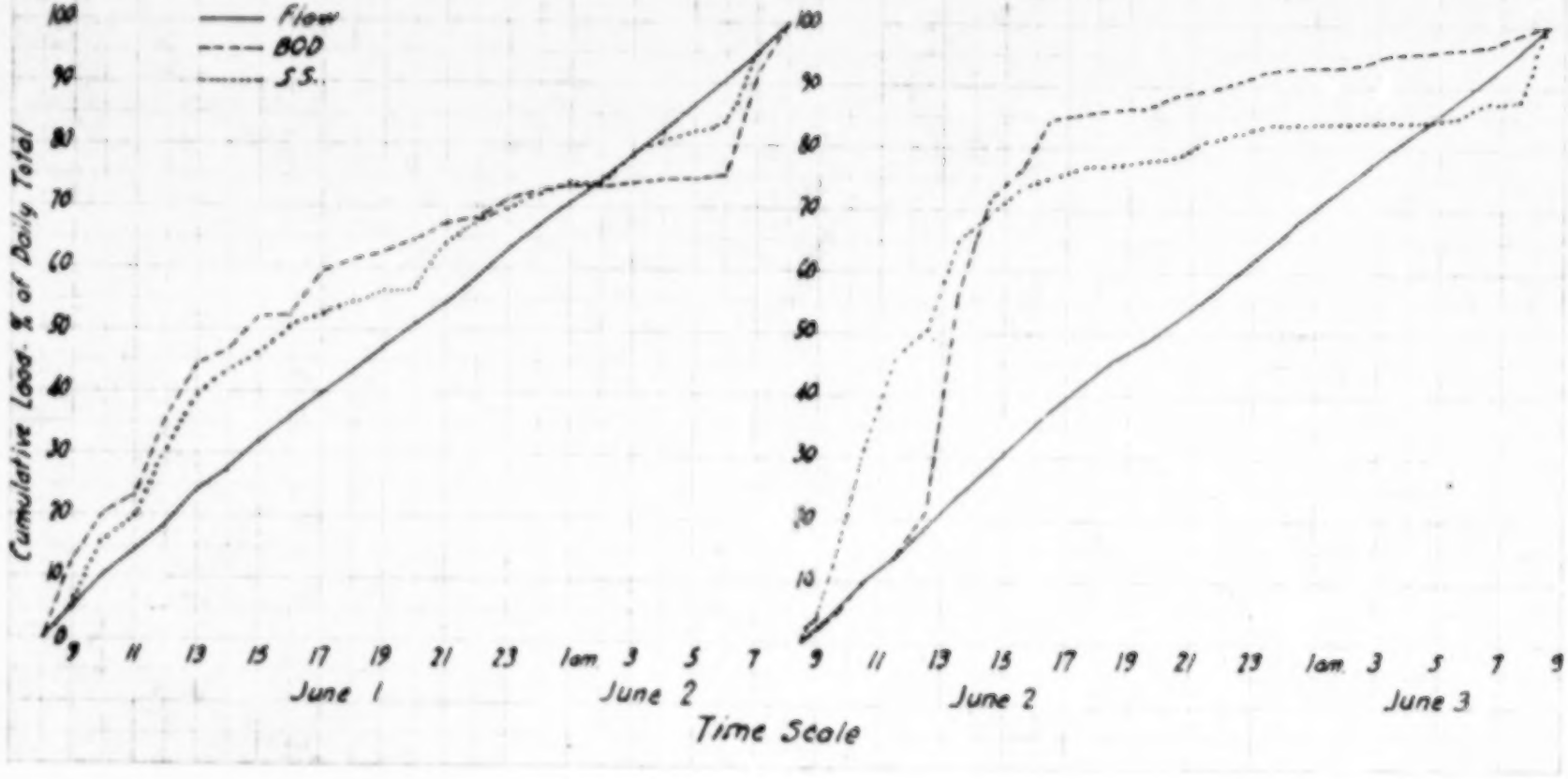
FIG. 5

MH - 38



NOT CLASSIFIED

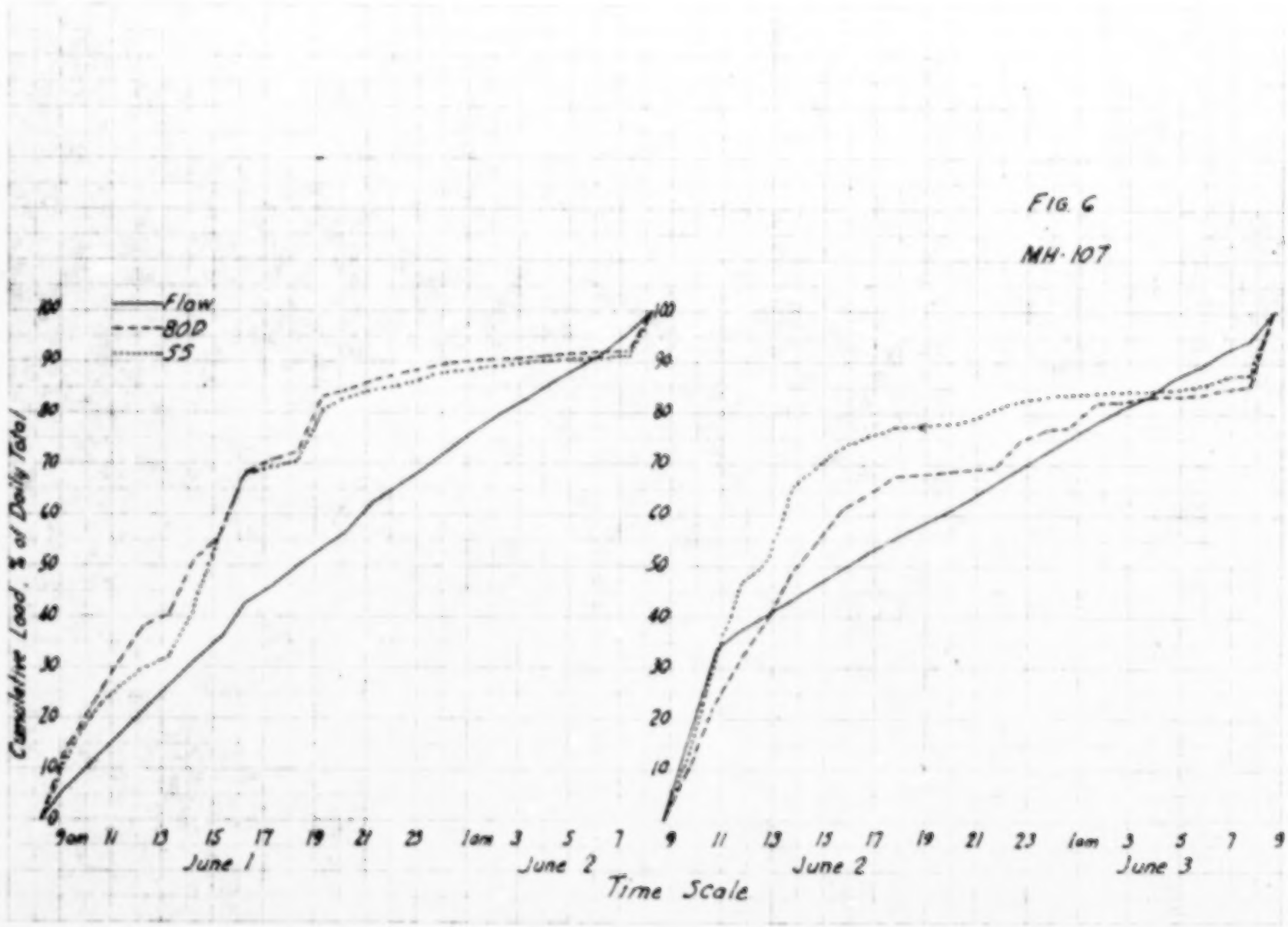


FIG. 6

MH-107

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